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Organizational Routines: An Agent Based Model Replication

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***Abstract*—this extended abstract focuses on organizational routines as an emergent phenomenon of individual behavior within collectives. Micro foundations related to dynamics of performing and remembering organizational routines are based on psychological constructs such as procedural, declarative and transactive memory. Replicating the agent-based model "Dynamics of Performing and Remembering Organizational Routines" in a different programming language is used to analyze the model´s credibility. To enhance the replication transparency and quality the existing model is initially transferred into an ODD protocol before its re-implementation. If the model can be replicated without significant errors, it can be used in further research to examine organizational routines in accounting.**

I. Introduction

Theory on organizational routines was revised in 2003, when Feldman and Pentland illustrated duality of organizational routines adhere a recursive connected performative and an ostensive aspect [2]. Miller et al. provided in 2012 an agent-based model to examine the roles of procedural, declarative and transactive memory related to a shared holistic ostensive routine. Therewith they presented the first multiple-agent simulation to model the micro-foundations of organizational routines [1]. Modelling groups of individuals facilitate to examine the internal structure and dynamics of organizational routines. This social simulation model is crucial to examine accounting routines in view of coordination of activities and organizational learning. Prior to adopt the model to an organizational accounting routine its credibility is tested with this model replication. Technical transferability of the model implemented in MATLAB 7 will be verified by its re-implementation in NetLogo 5.04. To enhance the replication transparency and quality the model is initially transferred into the revised ODD (Overview, Design concepts, Details) protocol originally suggested by Grimm et al. [3] [4]. Further the replication provides technical transparency to the first agent-based model, which is appropriate to examine the roles of procedural, declarative and transactive memory related to shared holistic ostensive routines [5].

II. Replication Design and Project Survey

1. *Initially ODD Transfer*

The replication project was started in February 2014 with the transfer of provided information into an ODD protocol. With this transfer process lacks of information are revealed. The complemented ODD protocol will be useful as universal basis for model implementations in different programming languages. The ODD protocol is actually close to completion and hence there is no lack of information.

2. *Re-Implementation in NetLogo 5.04*

NetLogo is chosen as implementation software, it is a widespread and typical agent-based simulation software based on an agent-based programming language Therefore it is different to MATLAB whose utilization is rather focused on numerical problems [6]. Furthermore MATLAB can be used with interface programs written in C, C++, Java and FORTRAN. Re-implementing the model in a different programming language countervails that any programming mistakes or assumptions will be repeated in the replication simulation [7]. This phase is scheduled for April and May 2014.

3. *Determine the Statistical Signature*

It is expected that the "overall" character of the simulation results of the replication model will be consistent with its original. However, an exact model alignment will be conducted until June to reveal minor bugs, ill-defined implementation issues, and to determine the so-called "statistical signature" [7].

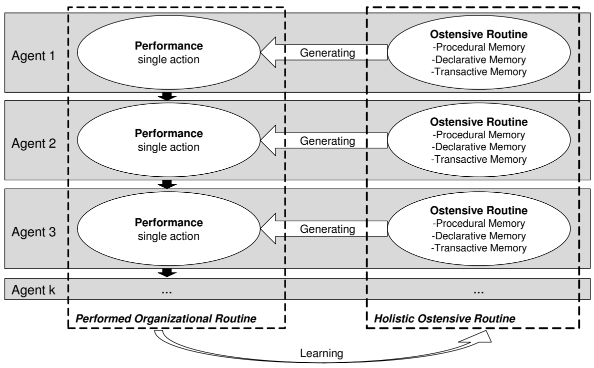

Fig. 1 Performative and ostensive aspect of an organizational routine

III. The Model

Organization and Problems

The general model setup is an organization, made up of *n* heterogeneous individuals who are capable of searching and learning due to transactive and declarative memory. Each agent represents an individual, which possess a skill and an awareness to recognize and perform tasks. Several tasks have to be performed by the individuals to solve a single recurring problem. The task order 1, 2,..., *k* represents a standard problem. New problems are assigned to an agent selected randomly among those able to complete the first required task. If an agent is not able complete the next sequential task, it transfers the problem to another agent who is able or remember a further skilled agent to perform the task. Each agent can complete on task per period. Upon completing a whole problem, the organization receives a new problem in the next period [1].

Task Awareness

The model allows to consider individual cognitive skills which are crucial for behavioral accounting research [8]. An agent is aware of *a* of possible *k* tasks ($1 \leq a \leq k$). Hence an agent is able to identify those tasks in its awareness set and blind to unfamiliar tasks [1].

Procedural Memory

In the original model each agent possesses a fixed single skill, which is content of the procedural memory. I am going to examine an increased number of skills in the re-implemented agent-based model to examine the opportunity of staff training [1].

Transactive Memory and Random Search

If an agent is not able to perform a task, it consults transactive memory to check, whether it remembers another agent that has the skill for the task. If consulting transactive memory is not successful the agent conducts a random search to find an agent with the required skill. During the random search the agent can ask the selected agent, whether it remembers another agent with the skill for the task. Transactive memory is updated with the probability p_t ($0 \leq p_t \leq 1$) after the searching agent has found an agent to whom the problem can be transferred. This updating process represents an individual learning process [1].

Declarative Memory

Agents learn from experience about the sequences in which tasks occur. As long as an agent is skilled to perform a task or can pass the task on to another agent, which possesses the required skill, it has the chance to learn the past two-step task sequence. This chance is represented by the probability p_d ($0 \leq p_d \leq 1$). Human individual bounded duration of remembrances is incorporated in the agent-based model by the factor w_d ($0 \leq w_d \leq \infty$) [1].

Output Parameter Cycle Time

The output parameter *cycle time* represents the number of periods the agents need to complete a proble. This is computed as the number of periods in which a task is completed plus the number of periods in which an agent´s search did not result in transferring a problem. Minimum *cycle time* and therefore maximum problem-solving efficiency occurs when the cycle time equals the number of tasks in a problem [1].

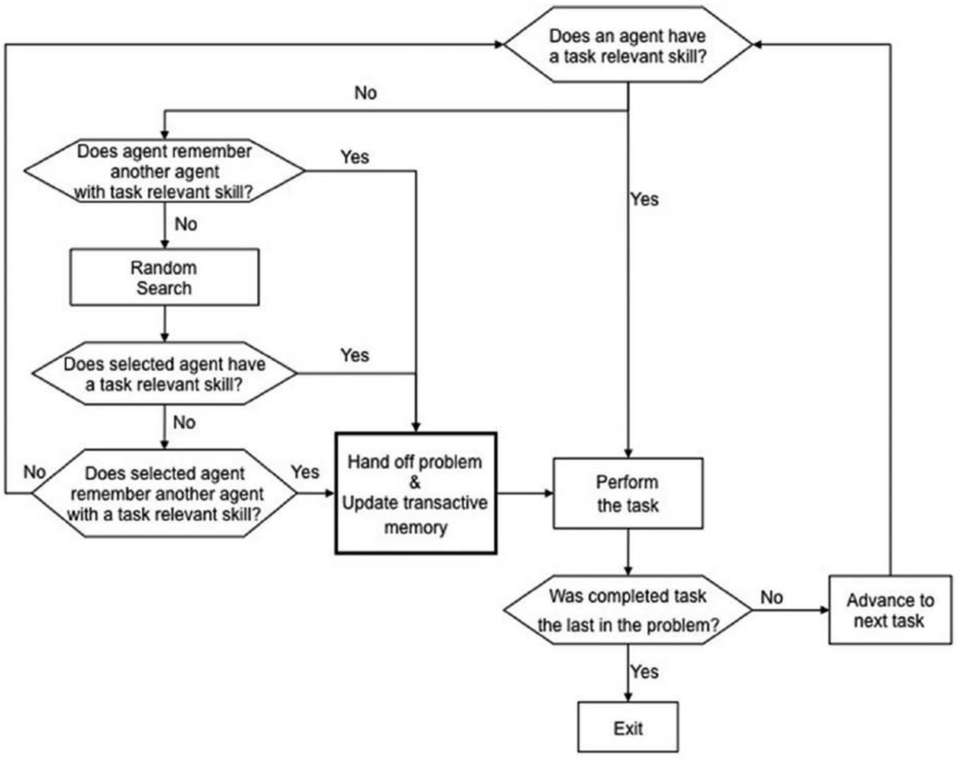

Fig. 2 Flow chart for search and task completion of the model [1]

TABLE I
MODEL PARAMETERS [1]

Parameter	Meaning	Default settings	Altered values in original model	Intended Additional value tests in the re-implemented model	Reasoning for additional tests
n	Number of agent in the organization	50	10, 30	>50	To examine Additional staff assignment
k	Number of different tasks in a problem	10	-	<10, >10	To examine routine complexity
a	Number of discernable tasks for any given agent (task awareness)	5	1, 10	-	-
p_t	Probability of adding an entry to an agent´s transactive memory	0.5	0.25, 0.75, 1.0	-	-
p_d	Probability of adding an entry to an agent´s declarative memory	0.5	0.25, 0.75, 1.0	-	-
w_d	Number of remembered subsequent tasks in declarative memory of a given performed task	1	50	-	-
s	Number of skills to solve tasks	1	-	>1	To examine staff training

IV. FURTHER EXPERIMENTS AND IMPROVEMENTS

After a successful model replication the following simulation experiments are scheduled, which are not conducted or mentioned in the paper “Dynamics of Performing and Remembering Organizational Routines” [1].

1. *Testing Additional Staff Assignment*

The replicated model was developed to examine personnel downsizing phenomenon in organizations. However it was not tested how the *cycle time* is effected by adding additional staff.

2. *Testing Staff Training*

It is expected that giving agents more than a single skill increases problem solving efficiency after a problem change or downsizing.

3. *Examine Routine Complexity*

The model could be beneficial to analyze the complexity of organizational routines. In particular varying the number of tasks in a problem admits to examine problem-solving efficiency for a single large problem e.g. $k = 100$ compared with a disaggregated problem with 10 task packets e.g. 10 * k ($k = 10$).

4. *Improved Output Measurement of Stability*

A first result is that the term stability is not adequately defined. There is no exact definition, when a routine is deemed to be stable. There is merely an indication given that a routine is stable, when it shows the same cycle time after a change occurred some periods before [1]. In practice organizational routine stability will be more target or context-dependent.

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